6.0 ALUMINUM

6.1 Summary

During the 1998 SWQB intensive water quality survey in the Upper Rio Chama Watershed, exceedences of the New Mexico water quality standard for chronic aluminum were documented at two sampling stations on Rio Chamita (SWQB Stations 4 and 7). Consequently, the Rio Chamita from Rio Chama to the Colorado border was listed on the 2000-2002 Clean Water Act §303(d) list for chronic aluminum.

The Village of Chama WWTP discharges into the Rio Chamita at SWQB station 6. The WWTP has a design capacity of 0.3 MGD average discharge and serves a population of approximately 400 persons. The plant is a lagoon system with chlorination and dechlorination that is monitored through NPDES permit #NM0027731 (SWQB/NMED 1999a). The current permit expires June 30, 2005. Because high instream concentrations of aluminum were noted during the 1998 study, the permit includes reference to a reopener clause that will allow the permit to be reopened to include aluminum limits once the TMDL is established and approved.

6.2 Endpoint Identification

Target Loading Capacity

Target values for this chronic aluminum TMDL will be determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document, target values for dissolved aluminum are based on numeric criteria. This TMDL is also consistent with New Mexico's antidegradation policy.

According to the New Mexico water quality standards (20.6.4.900.M NMAC), the dissolved aluminum chronic criterion is 87 µg/L and the dissolved aluminum acute criterion is 750 µg/L for aquatic life uses.

High chronic levels of dissolved aluminum can be toxic to fish, benthic invertebrates, and some single-celled plants. Aluminum concentrations from 100 to 300 µg/L increase mortality, retard growth, gonadal development and egg production of fish (http://h2osparc.wq.ncsu.edu). To be conservative, these TMDLs were drafted for chronic aluminum and, therefore, should also protect against any acute exceedences.

Data was collected from the Rio Chamita at the Highway 29 crossing (SWQB station 4) and from the Rio Chamita below the Village of Chama Wastewater Treatment Plant (WWTP) (SWQB station 7) eight times between June 1 and October 21, 1998 (Table 6.1). Dissolved aluminum concentrations exceeded the chronic criterion for aluminum during spring sampling. The calculated dissolved aluminum 4-day average during the spring sampling run was 92.5 µg /L at station 4 and 145 µg /L at station 7. Aluminum was not detected at these two stations during the summer and fall seasons in 1998. Concurrently collected total suspended solids (TSS) data reported in Table 6.1 will be discussed in the Linkage(s) section below.

Table 6.1 Dissolved aluminum (Al) and total suspended solids (TSS) concentrations in the Rio Chamita

Sample Date	SWQB Station 4		SWQB Station 7	
	Dissolved Al (μg /L)	TSS (mg/L)	Dissolved Al (μg /L)	TSS (mg/L)
980601	120*	15	190*	15
980602	140*	14	130*	28
980603	70	21	70	25
980604	40	18	190*	22
980818	10K	12	10K	18
980819	10K	13	10K	not available
981020	10K	10	10K	6
981021	not available	3K	10K	not available

K = reported as "below detection limit"
* Exceedence of 87 µg /L dissolved aluminum chronic water quality criterion.

Flow

TMDLs are calculated for the Rio Chamita at a specific flow. Metal concentrations in a stream vary as a function of flow. As flow increases the concentration of metals can increase. When available, USGS gages are used to estimate flow. Where gages are absent, geomorphologic cross section field data are collected at each site and flows are modeled or actual flow measurements are taken. In this case, flow was measured on the Rio Chamita at SWQB station 5 (upstream of the WWTP) during the spring sampling run using standard USGS procedures (SWQB/NMED 2001a). The measured flow value was 27.0 cfs. Therefore,

RIO CHAMITA critical flow --
Q_{MSR} = 27.0 cfs (1 cfs/1.5473 mgd)
Q_{MSR} = 17.4 mgd

The combined flow is calculated by adding the critical flow and the average design flow contribution from any point sources. The WWTP has a design capacity of 0.3 MGD average discharge. Therefore,

RIO CHAMITA combined flow –
$Q_{MSR} + Q_{DESIGN}$ = 17.4 mgd + 0.3 mgd = 17.7 mgd

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems, the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained. Meeting the calculated target load may be a difficult objective.

Calculations

A target load for chronic aluminum is calculated based on a flow, the current water quality criterion, and a conversion factor (8.34) that is a used to convert mg/L units to lbs/day (see Appendix B for Conversion Factor Derivation). The target loading capacity is calculated using Equation 1. The results are shown in Table 6.2.

Equation 1. *combined flow (mgd) x standard (mg/L) x 8.34 (conversion factor) = target loading capacity*

Table 6.2 Calculation of target loads for chronic dissolved aluminum

Location	Combined Flow+ (mgd)	Dissolved Al chronic criterion (mg/L)	Conversion Factor	Target Load Capacity (lbs/day)
Rio Chamita	17.7	0.087	8.34	12.8

+ Since USGS gages were unavailable, flow was measured during the 1998 spring sampling run (SWQB/NMED 2001a). This value was added to the design flow of the WWTP to estimate the combined instream flow below the WWTP.

The measured loads for dissolved aluminum were similarly calculated. The arithmetic mean of the data from the site downstream of the WWTP (station 7) collected during the spring run was substituted for the standard in Equation 1. Dissolved aluminum concentrations were not measured at the WWTP outlet (station 6) during the 1998 survey. Concentrations at station 7 include any potential contributions to the measured load from the WWTP. The calculated dissolved aluminum 4-day average during the spring sampling run was 145 µg /L (0.145 mg/L) at station 7. The same conversion factor of 8.34 was used. Results are presented in Table 6.3.

Table 6.3 Calculation of measured loads for chronic dissolved aluminum

Pollutant sources in Rio Chamita	Flow (mgd)	Dissolved Al Arithmetic Mean * (mg/L)	Conversion Factor	Measured Load Capacity (lbs/day)
Rio Chamita	17.7	0.145	8.34	21.4

* Arithmetic mean of dissolved aluminum concentration at station 7 during the spring sampling run (see Table 6.1).

Waste Load Allocations and Load Allocations

•Waste Load Allocation

There is one point source contributor associated with this TMDL. As noted above, the Village of Chama WWTP discharges into the Rio Chamita at SWQB station 6 and is monitored through NPDES permit #NM0027731 (SWQB/NMED 1999a). There is currently no discharge limit for dissolved aluminum in the permit. Because high instream concentrations of aluminum were noted during the 1998 study, the permit includes reference to a reopener clause that will allow the permit to be reopened to include aluminum limits once the TMDL is established and approved.

Because the WWTP discharges into a stream reach that is listed for dissolved aluminum, they are required to monitor and report on dissolved aluminum limits once per quarter as stated in their NPDES permit. The plant operators have sampled aluminum during two quarters, but the lab analyzed for total aluminum instead of dissolved aluminum. SWQB staff sampled the WWTP effluent in October of 2002 as part of an NPDES compliance sampling inspection. The concentration of dissolved aluminum during this sampling event was 0.14 mg/L. This is only available data point available to determine a potential dissolved aluminum waste load allocation for the WWTP. Given a design flow of 0.3 MGD, a concentration of 0.14 mg/L, and the conversion factor of 8.34, a WLA of 0.4 lbs/day was calculated.

•*Load Allocation*
In order to calculate the Load Allocation (LA), the WLA and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

The MOS is estimated to be 20% of the target load calculated in Table 6.2. Results are presented in Table 6.4. Additional details on the MOS chosen are presented in section 6.3 below.

Table 6.4 Calculation of TMDL for chronic dissolved aluminum

Location	WLA (lbs/day)	LA (lbs/day)	MOS (20%) (lbs/day)	TMDL (lbs/day)
Rio Chamita	0.4	9.8	2.6	12.8

The extensive data collection and analyses necessary to determine background dissolved aluminum loads for the Rio Chamita watershed was beyond the resources available for this study. It is therefore assumed that a portion of the load allocation is made up of natural background loads.

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the calculated target load allocation (Tables 6.2 and 6.4) and the measured load (Table 6.3), and are shown in Table 6.5.

Table 6.5 Calculation of load reduction for chronic dissolved aluminum

Location	Target Load (lbs/day)	Measured Load (lbs/day)	Load Reduction (lb/day)
Rio Chamita	12.8	21.4	8.6

Identification and Description of pollutant source(s)

Pollutant sources that could contribute to each segment are listed in Table 6.6.

Table 6.6 Pollutant source summary for chronic dissolved aluminum

Pollutant Sources	**Magnitude**	**Location**	**Potential Sources** (% from each)
<u>Point</u>: Village of Chamita WWTP	0.4	Rio Chamita	4% Municipal Point Source
<u>Nonpoint</u>:	9.8	Rio Chamita	96% Elk Range Grazing Road Maintenance and Runoff Natural Sources/ Geology

Linkage of Water Quality and Pollutant Sources

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED 1999c). The completed Pollutant Source(s) Documentation Protocol forms in Appendix C provide documentation of a visual analysis of probable sources along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 6.6 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. It is important to consider not only the land directly adjacent to the stream, which is predominantly state and privately managed land, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL.

Aluminum is the most common metal in the Earth's crust and the third most common element. Aluminum comprises, on average, about eight percent of the Earth's crust. In general, increased metals in the water column can commonly be linked to sediment transport and accumulation, where the metals are a constituent part of the sediment. This does not appear to be the case in the Rio Chamita as evidenced by the fact that there is not a relationship between dissolved aluminum and total suspended solids concentrations (TSS) at station 4 according to the 1998 sampling data (Table 6.1, Figure 6.1). The TSS method is a commonly used measurement of suspended material in surface water. This method was originally developed for use on wastewater samples, but has widely been used as a measure of suspended materials in stream samples because it is acceptable for regulatory purposes and is an inexpensive laboratory procedure. Since there are no wastewater treatment plants discharging into Rio Chamita above station 4, it is assumed that TSS measurements at this station are representative of erosional activities and thus comprised primarily of suspended sediment vs. any potential biosolids from wastewater treatment plant effluent.

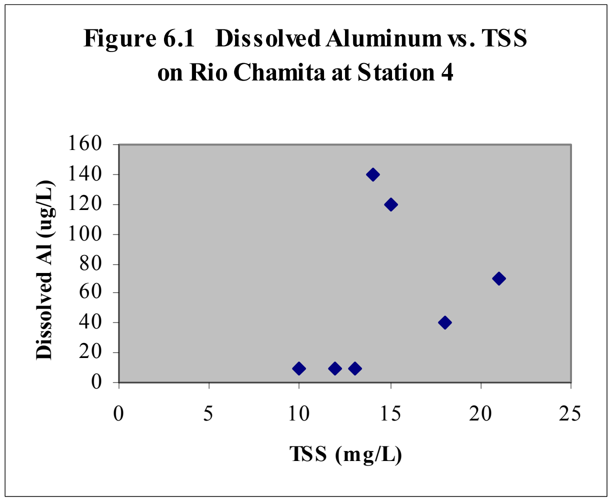

Figure 6.1 Relationship between Dissolved Aluminum and TSS in Rio Chamita at station 4 (above the WWTP)

High aluminum is characteristic of the spring snowmelt/runoff period and is not pronounced during baseflow conditions in the Rio Chamita. Normal aqueous chemical processes, enhanced by the slight natural acidity of snow and rain, are capable of rendering some of this abundant, naturally-occurring aluminum available to the stream system. The fact that high dissolved aluminum concentrations were measured during the spring sampling run as opposed to below detection limit concentrations during summer and fall sampling runs are indicative of a landscape source. Acidic anions as well as carbonic acid carried in snow are released into the soil as the snow melts and bring aluminum species into solution. Thus, aluminum concentrations are often high during spring runoff in many areas in New Mexico despite the expected diluting effects of high flow.

The predominant geologic formation in the lower to middle portions of the watershed is Mancos Shale (see figure 1.2). The middle portion contains a band from the Mesa Verde group. Lower Cretaceous formations occupy the upper portion of the watershed. Although volcanic formations in the watershed would provide a stronger explanation for elevated aluminum, Mancos Shale can be an accumulation unit for metals transported from volcanic activity in the surrounding area. The Mesa Verde group could also contain beach sand components resulting from surrounding volcanic activity.

Also, approximately 32 mi^2 of the upper watershed area are protected within the Edward Sargent Fish and Wildlife Area that was established in 1978 and is managed by NMDGF. Domestic livestock grazing is excluded and public access is restricted to foot and horseback traffic. Impacts are limited to elk herds that reside in the area. There are no known existing or historic aluminum mines in the watershed. In the absence of identifiable degraded uplands, anthropogenic sources of aluminum, poor streambank condition, or land use impacts to explain high levels of sedimentation that may have led to high aluminum concentrations, the largest probable source for high aluminum concentrations measured during snowmelt runoff appears to be local watershed bedrock and natural surface geology processes.

The potential waste load allocation of aluminum from the WWTP (0.35 lbs/day) is negligible compared to total measured load contributed during spring runoff (21.4 lbs/day). Even during baseflow conditions, input from the WWTP does not appear to exceed the assimilative capacity of the Rio Chamita based on the 1998 survey data because all baseflow concentrations of aluminum in the Rio Chamita were below the detection limit (<0.01 mg/L) at station 7. Additionally, the Village of Chama WWTP operators have begun discussing the possibility of re-directing their outfall from the Rio Chamita to the Rio Chama to take advantage of the increased assimilative capacity of the Rio Chama. During the October 2002, SWQB staff noted several potential sources of aluminum, such as aluminum weirs, screens, and gates. They may consider installing non-aluminum replacement fixtures to eliminate these potential sources of aluminum at the WWTP.

6.3 Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for nonpoint sources the margin of safety is estimated to be an addition of **20%** for aluminum in this case, excluding background. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*

A level of uncertainty exists in sampling nonpoint sources of pollution. Techniques used for measuring metals concentrations in stream water are $\pm$15% accurate according to the QAPP (SWQB/NMED 2001b). Accordingly, a conservative margin of safety for metals increases the TMDL by **15%.**

•*Errors in calculating flow*

Flow estimates were based on one measurement during the spring sampling run. Instrument and operator error can lead to inaccuracy in flow measurements. Accordingly, a conservative margin of safety increases the TMDL by an additional **5%.**

6.4 Consideration of Seasonal Variation

Data used in the calculation of this TMDL were collected during the spring, summer, and fall of 1998 in order to ensure coverage of any potential seasonal variation in the system. Critical condition is set to high flow for dissolved aluminum because data exceedences were observed during high spring flows. A flow measurement taken during the spring sampling run was used in the calculations.

6.5 Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for chronic aluminum that cannot be controlled with best management practice (BMP) implementation in this watershed. According to the US Census bureau, the population of Rio Arriba county was reduced by 141 persons (0.34 %) between July 1, 2000, and July 1, 2002. Therefore, a growth allocation was not included in the waste load allocation.